

CLAIMS

What is claimed is:

Claim 1 - A low emissions hydrocarbon combustion power generation system, featuring ion transport membrane air separation, comprising in combination:

an ion transport membrane air separator having an air inlet and an oxygen outlet for a stream of gas having a greater percentage of oxygen than a percentage of oxygen existing in the air;

a source of hydrocarbon fuel;

a gas generator adapted to combust the hydrocarbon fuel from said source of hydrocarbon fuel with oxygen from said oxygen outlet of said ion transport membrane air separator, to produce products of combustion including water and carbon dioxide, said gas generator including an outlet for said products of combustion;

a first turbine downstream from said gas generator outlet, said first turbine adapted to expand the products of combustion and output power, and having a discharge; and

an air preheater upstream of said air inlet into said ion transport membrane air separator, said air preheater adapted to be at least partially heated with heat from products of combustion between said gas generator outlet and a last turbine downstream from said outlet of said gas generator.

Claim 2 - The power generation system of Claim 1 wherein a source of a diluent is provided upstream from said gas generator, said diluent source adapted to add diluent into said gas generator for addition of the diluent to the products of combustion.

Claim 3 - The power generation system of Claim 2 wherein said source of diluent is a source of primarily water.

Claim 4 - The power generation system of Claim 3 wherein said source of diluent is a source of primarily carbon dioxide.

Claim 5 - The power generation system of Claim 3 wherein said source of diluent is a source of a mixture of substantially only water and carbon dioxide.

Claim 6 - The power generation system of Claim 2 wherein said system includes a combustion products separator located downstream from said last turbine, said separator adapted to receive the products of combustion including water and carbon dioxide therein in primarily a gaseous phase, said separator adapted to condense at least a portion of water therein and discharge liquid products of combustion including primarily water from said separator, said liquid outlet of primarily water coupled to said source of diluent, such that said source of diluent is supplied with water from said separator and at least a portion of water generated as a product of combustion of the hydrocarbon fuel and the oxygen within said gas generator is recirculated to said gas generator through said source of diluent.

Claim 7 - The power generation system of Claim 6 wherein said separator includes a gaseous outlet for primarily carbon dioxide, said carbon dioxide outlet coupled to a carbon dioxide sequestration subsystem adapted to contain the carbon dioxide away from ambient atmosphere, such that the carbon dioxide is not emitted into the atmosphere by the power generation system.

Claim 8 - The power generation system of Claim 1 wherein said system includes a combustion products separator located downstream from said last turbine, said separator adapted to receive the products of combustion including water and carbon dioxide therein in primarily a gaseous phase, said separator adapted to condense at least a portion of water therein and discharge liquid products of combustion including primarily water from said separator, said liquid outlet of primarily water coupled to said source of diluent, such that said source of diluent is supplied with water from said separator and at least a portion of water generated as a product of combustion of the hydrocarbon fuel and the oxygen within said gas generator is recirculated to said gas generator through said source of diluent; and

wherein said liquid outlet of said separator is coupled to a water line leading to said gas generator for input into said gas generator, said water line routed through at least one feed water heater in heat transfer relationship with products of combustion between said outlet of said gas generator and said combustion products separator, such that water in said water line is preheated before entering said gas generator.

Claim 9 - The power generation system of Claim 8 wherein said at least one feed water heater is located between said last turbine and said separator.

Claim 10 - The power generation system of Claim 8 wherein said at least one feed water heater is located between said outlet of said gas generator and said first turbine.

Claim 11 - The power generation system of Claim 8 wherein said at least one feed water heater is located between said first turbine and a second turbine downstream from said first turbine and upstream from said separator.

Claim 12 - The power generation system of Claim 8 wherein said water line includes at least two feed water heaters in heat transfer relationship with the products of combustion between said gas generator and said combustion products separator, a first of said at least two feed water heaters located between said last turbine and said combustion products separator, and a second of said at least two feed water heaters located between said first turbine and a second turbine located downstream from said first turbine and upstream from said combustion products separator.

Claim 13 - The power generation system of Claim 1 wherein a reheater is located downstream from said first turbine discharge, said reheater adapted to combust the fuel from said source of hydrocarbon fuel with the oxygen from said oxygen outlet of said ion transfer membrane air separator to produce products of combustion including water and carbon dioxide and to add the products of combustion of said gas generator to produce combined products of combustion of steam and carbon dioxide; and

a second turbine downstream from said reheater, said second turbine adapted to expand the combined products of combustion and output power.

Claim 14 - The power generation system of Claim 13 wherein an air preheater diversion line is provided between said gas generator and said last turbine, said diversion line adapted to divert products of combustion to a heat exchanger for heating air entering said air preheater and returning the products of combustion between said gas generator and said last turbine.

Claim 15 - The power generation system of Claim 14 wherein said diversion line returns the products of combustion from said air preheater upstream from said last turbine.

Claim 16 - The power generation system of Claim 15 wherein said diversion line removes the products of combustion from a location downstream from said reheater and upstream of said second turbine for delivery of the products of combustion along said diversion line to said air preheater.

Claim 17 - A low emissions hydrocarbon combustion power generation system featuring regenerative heating, comprising in combination:

- an air separator adapted to separate at least a portion of oxygen from other constituents within ambient air entering said air separator through an oxygen outlet;

- a source of hydrocarbon fuel;

- a source of diluent;

- a gas generator adapted to combust the fuel from said source of hydrocarbon fuel with oxygen from said oxygen outlet of said air separator to produce products of combustion including water and carbon dioxide, said gas generator including an outlet for the products of combustion, said gas generator adapted to add the diluent from said source of diluent to the products of combustion produced within said gas generator with a combination of the diluent and the products of combustion produced within the gas generator discharged through said gas generator outlet;

- a first turbine downstream from said gas generator outlet, said turbine adapted to expand the products of combustion and the diluent, as well as output power, said first

turbine having a discharge; and

at least one diluent heater adapted to heat the diluent before the diluent enters said gas generator, said diluent heater in heat transfer relationship with the products of combustion downstream from said gas generator, such that at least a portion of heat within the products of combustion is transferred to the diluent before the diluent enters said gas generator.

Claim 18 - The system of Claim 17 wherein a combustion products separator is located downstream from said first turbine, said combustion products separator including an inlet for the combined products of combustion and the diluent and at least two outlets including a primarily water outlet and a primarily carbon dioxide outlet, said primarily water outlet coupled to a feed water line leading to said source of diluent, such that said source of diluent is a source of primarily water diluent.

Claim 19 - The system of Claim 18 wherein said at least one diluent heater is located between a last turbine downstream from said gas generator and said combustion products separator.

Claim 20 - The system of Claim 17 wherein a reheater is located downstream from said first turbine discharge, said reheater adapted to combust hydrocarbon fuel from said source of hydrocarbon fuel with oxygen from said oxygen outlet of said air separator, and to mix the products of combustion produced within said gas generator and the diluent with products of combustion produced within said reheater to produce combined products of combustion discharged through a reheater outlet; and

a second turbine downstream from said reheater, said second turbine adapted to expand the combined products of combustion and output power, and having a second turbine discharge.

Claim 21 - The system of Claim 20 wherein said at least one diluent heater is located between said first turbine and said reheater downstream from said gas generator.

Claim 22 - The system of Claim 21 wherein a combustion products separator is located downstream from said last turbine, said separator including an inlet for the combined products of combustion and the diluent and at least two outlets including a primarily water outlet and a primarily carbon dioxide outlet, said primarily water outlet coupled to a feed water line leading to said source of diluent, such that said source of diluent is a source of primarily water diluent.

Claim 23 - The system of Claim 22 wherein a second diluent heater is located between said last turbine and said separator.

Claim 24 - The system of Claim 23 wherein a second reheater is located downstream from said second turbine discharge, said second reheater adapted to combust hydrocarbon fuel with oxygen, and to mix fluids from said second turbine discharge with products of combustion produced within said second reheater to produce combined products of combustion discharged through said second reheater outlet; and

a third turbine downstream from said second reheater, said third turbine adapted to expand the combined products of combustion and output power, and having a third turbine discharge.

Claim 25 - The system of Claim 24 wherein a third diluent heater is located between said second turbine and said second reheater.

Claim 26 - The system of Claim 17 wherein said air separator includes an ion transfer membrane.

Claim 27 - The system of Claim 26 wherein an air preheater is located upstream of said air inlet into said ion transfer membrane air separator, said air preheater adapted to at least partially be heated with heat from the products of combustion between said gas generator outlet and a last turbine downstream from said gas generator.